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ROUTE REDISTRIBUTION: BEYOND INHERENT METRICS

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ABSTRACT

Route redistributions are considered necessary in various contexts, some of which are as a result of multiple departments managed by multiple network administrators, multi-vendor environments and company mergers. This study set out to redistribute routes between RIP and EIGRP routing protocols and assess the performance beyond inherent metrics. Round trip times over varied bandwidths were used as a basis for comparison with RIP and EIGRP used as the routing protocols. An experiment was set up using the Packet Tracer simulator and two separate networks were integrated via route redistribution of the two routing protocols. Despite regular surges in data transmission as a result inherent routing protocols' propagation of learned routes and advertisements, the results obtained from the experiment suggests that inherent metrics of the routing protocols do still play a significant role and is an integral component in determining performance of network links with redistributed routes.

KEYWORDS: Routing Protocols, Route Redistribution & Routing Metrics

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Original Article

INTRODUCTION

The use of dynamic routing protocols have become prominent in modern large-scale networks. They tend to be the most effective and efficient routing methods to support modern network on a large scale as against static routing. Dynamic routing protocols may be implemented to reduce administrative work and also make room for scalability of networks. Routing dynamically requires the implementation and configuration of routing protocols, which are a set of rules by which routers share some information about the connectivity, path to destination and networks' availability. The procedure makes use of routing metrics that are determined through specific routing algorithms of the specific routing protocol in use. When routing protocols are used to advertise routes obtained by different means, for example, by static routes, interfaces that are directly connected or through other routing protocols, this is referred to as route redistribution. This situation never arises in the case of single protocol routing environment but multi-protocol routing is common for a number of reasons, like company mergers, multiple departments managed by multiple network administrators and multi-vendor environments".[1] The route redistribution aims at two possible objectives, the "first goal is to advertise routing information between different routing protocols for connectivity purposes. The second goal is route back up in case of a network failure, routing protocol should support alternate forwarding paths to each other". Moreover, the solutions are most applicable to circumstances with just two routing protocols, but relatively enormous working networks usually include multiple (more than two) routing protocols[2].

The objective of this research is to redistribute routes between RIP and EIGRP routing protocols and assess the performance beyond inherent metrics. Specifically, network round trip times over varied bandwidths are used as a basis for comparison. The Routing Information Protocol (RIP) version 2 and the Enhanced Interior Gateway Routing Protocols (EIGRP) are used in the experiment.

LITERATURE REVIEW

The Routing Protocols in Context

Routing Information Protocol (RIP): This routing protocol is a distance-vector routing protocol which leverages on hop count as its routing metric. RIP makes use of limits on the number of hops allowed to prevent possible routing loops between source and destination. RIP by default is designed to permit a maximum of 15 router hops between source and destination of communicating devices, this unvaryingly tends to limit the reach of RIP-based networks. "RIP leverages on a number of algorithms to prevent routing loops or the propagation of incorrect routing information. This is achieved by the implementation of the split horizon, route poisoning and hold-down mechanisms to prevent wrong information from being propagated"[3]. RIP-based routers are by default configured to broadcast updates with their routing table with a 30-seconds interval. This implies that a RIP-based router will exchange routing table every 30 seconds due to surges in data transmission experienced every 30 seconds even if the routers had been initialized at random times. RIP has not been successful in scaling as networks have grown.[4] RIP is class full and as such does assume the default subnet mask during broadcast updates of the routing tables. Given its relatively fewer parameters for configuration, it is relatively less difficult to configure compared with other routing protocols. RIP version 2 (RIPv2) was introduced as a result of challenges in implementation of RIP. RIP version 2 was developed with the ability to transmit subnet information during the exchange of routing updates for routing tables, thereby supporting Classless Inter-Domain Routing (CIDR). To make sure that it was backward compatible with RIP, the hop count limit of 15 was maintained. "RIPv2 has facilities to fully interoperate with the earlier specification"5. To avoid a situation where unnecessary load is put on hosts that do not participate in routing, RIPv2 multicasts the entire routing table to all adjacent routers at the address 224.0.0.9 unlike RIPv1 which uses broadcast.

Enhanced Interior Gateway Routing Protocol (EIGRP) is also a distance-vector routing protocol but with advanced capability. It is a routing protocol that is used to mechanize routing decisions and configuration.[3] The protocol was originally designed by Cisco Systems and also originally designed as a proprietary routing protocol on Cisco devices only for the purpose of sharing routes with other routers within a single administrative domain or the same autonomous system. The EIGRP architecture is built to only share incremental routing updates and as a result leads to a reduction in the amount of work on the routers and the amount of data that needs to be transmitted. EIGRP operates in such a way that almost all routers contain a routing table which has embedded rules by which traffic is forwarded in a network. Technically, EIGRP paces the rate at which it transmits packets on multi-point links with less than 1500 kb/s bandwidth. The default HELLO time on these links are 60 seconds with a HOLD time of 180 seconds. The "bandwidth" configured on the interface determines the rate of packets. EIGRP works with tables called neighbour, topology and routing table to store information about the network and how to reach destinations. When an EIGRP configured router interconnects other EIGRP routers, they build a relationship referred to as adjacency. This is based on exchanged information between the two routers. The entire routing table is exchanged between both routers at this time. After this has occurred, only differential changes are sent.[6] This routing protocol (EIGRP) is also frequently referred to as a hybrid protocol, thus both a distant vector and link state, because it also sends link state updates when link states change. It is relatively optimal as compared to RIP in bigger sized networks because it updates only when a network topology is altered but not necessarily regularly or periodically unlike typically old Distance-Vector routing protocols such as RIP. The EIGRP metric is based on its bandwidth, delay, reliability, load and Maximum Transmission Unit (MTU).

Route Redistribution Metrics

When routing protocols are redistributed into each other, each protocol's routing metrics uniquely influences the redistribution by playing a uniquely important role. On the premise of the uniquely varying metrics, this contextual experiment of using the Routing Information Protocol (RIP)'s metric which is based on hop count, whereas Enhanced Interior Gateway Routing Protocol (EIGRP) leverages on a composite metric, which uses bandwidth, delay, reliability, load and maximum transmission unit (MTU). It is worth noting that EIGRP relies on bandwidth and delay as the only parameters used by default as the metric for path determination.[7] When routes are redistributed, a metric must be defined that can be comprehended by the receiving protocol. The routes are redistributed differently depending on the specific routing protocol to which the redistribution is being made. The platform or vendor equipment may handle some specific parameters slightly differently if the metric in question is not configured by default. The context in question is however a simulated Cisco environment.

METHODOLOGY

This study simulates the networks in an experimental setting using a simulation software called Packet Tracer. Simulated research work is viewed from three perspectives in literature. The use of simulation is primarily the use of controlled, consistent computational methods to answer analytically obdurate equations. Another view of simulation is a stand-in or mimic of a real-world system which can, therefore, be experimented on just like any other experimental target.[8]. This research specifically uses a simulator called Packet Tracer developed by Cisco Systems to technically generate and compare the output of route redistribution between routing protocols, as they converge and route data on separate interconnected networks. The comparison is done using the round-trip time. Round-trip time (RTT) is defined as the length of time taken for a signal to be sent plus the length of time it takes for an acknowledgement of the signal to be received. The time delay in this context also includes the propagation times for the paths between the two communication endpoints.[9] The ultimate comparison of the RTT for varied bandwidths depicts the extent to which inherent metrics influence the efficiency of route redistribution comparatively, the model of routers used was Cisco 2900 at all routing points. Below is a figure showing the layout of the network.

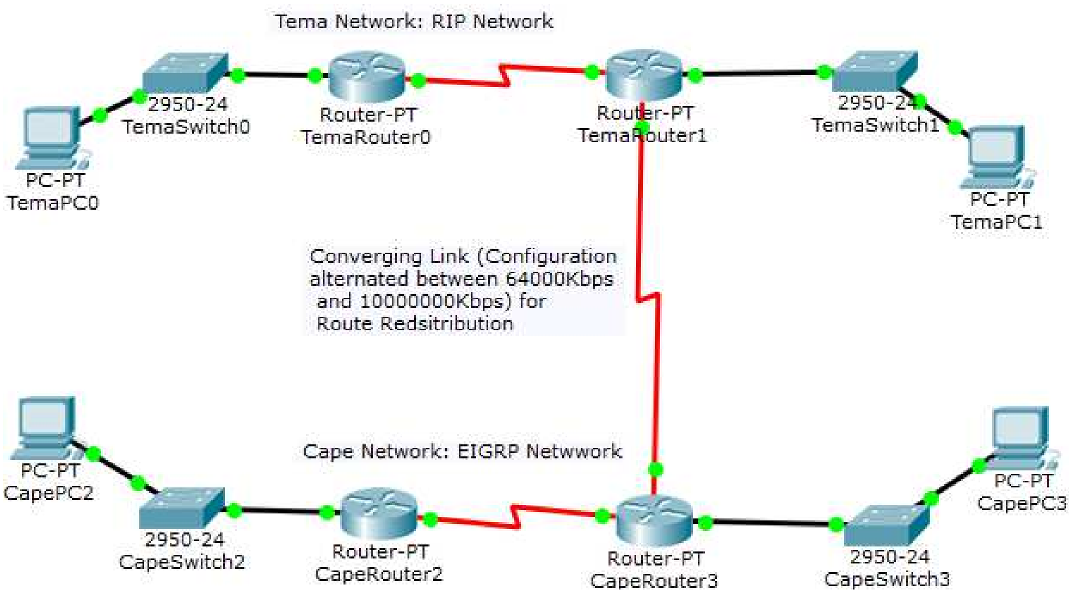

Figure 1: Topology of Lab Setup.
Source: Author(s)

Configuration

The specific machine names and their respective configurations are provided below; the essence is to provide a broad overview of the simulated environment.

Table 1: Address Configuration of Computers

No	Computers	IP Address
1	TemaPC0	10.0.0.1/8
2	TemaPC1	20.0.0.1/8
3	CapePC2	3.0.0.1/8
4	CapePC3	40.0.0.1/8

No	Routers	Configuration for 64000Kbps Interconnection Link	Altered Configuration for 10000000Kbps Interconnection Link
1	TemaRouter0	interface FastEthernet0/0 ip address 10.0.0.10 255.0.0.0 duplex auto speed auto interface FastEthernet1/0 no ip address duplex auto speed auto shutdown interface Serial2/0 ip address 30.0.0.1 255.0.0.0 clock rate 64000 interface Serial3/0 no ip address clock rate 2000000 shutdown router rip version 2 network 10.0.0.0 network 30.0.0.0	interface FastEthernet0/0 ip address 10.0.0.10 255.0.0.0 duplex auto speed auto interface FastEthernet1/0 no ip address duplex auto speed auto shutdown interface Serial2/0 ip address 30.0.0.1 255.0.0.0 clock rate 64000 interface Serial3/0 no ip address clock rate 2000000 shutdown router rip version 2 network 10.0.0.0 network 30.0.0.0
2	TemaRouter1	interface FastEthernet0/0 ip address 20.0.0.10 255.0.0.0 duplex auto speed auto interface FastEthernet1/0 no ip address duplex auto speed auto shutdown interface Serial2/0 ip address 30.0.0.2 255.0.0.0 interface Serial3/0 bandwidth 64000 ip address 70.0.0.1 255.0.0.0 clock rate 64000 router eigrp 10 network 20.0.0.0 network 30.0.0.0 network 70.0.0.0 auto-summary router rip version 2	interface FastEthernet0/0 ip address 20.0.0.10 255.0.0.0 duplex auto speed auto interface FastEthernet1/0 no ip address duplex auto speed auto shutdown interface Serial2/0 ip address 30.0.0.2 255.0.0.0 interface Serial3/0 bandwidth 10000000 ip address 70.0.0.1 255.0.0.0 clock rate 64000 router eigrp 10 network 20.0.0.0 network 30.0.0.0 network 70.0.0.0 auto-summary router rip version 2

		redistribute eigrp 10 metric 5 network 20.0.0.0 network 30.0.0.0 network 70.0.0.0	redistribute eigrp 10 metric 5 network 20.0.0.0 network 30.0.0.0 network 70.0.0.0
3	CapeRouter2	interface FastEthernet0/0 ip address 40.0.0.10 255.0.0.0 duplex auto speed auto interface FastEthernet1/0 no ip address duplex auto speed auto shutdown interface Serial2/0 ip address 60.0.0.1 255.0.0.0 clock rate 64000 interface Serial3/0 no ip address clock rate 2000000 shutdown router eigrp 10 network 40.0.0.0 network 60.0.0.0 auto-summary	interface FastEthernet0/0 ip address 40.0.0.10 255.0.0.0 duplex auto speed auto interface FastEthernet1/0 no ip address duplex auto speed auto shutdown interface Serial2/0 ip address 60.0.0.1 255.0.0.0 clock rate 64000 interface Serial3/0 no ip address clock rate 2000000 shutdown router eigrp 10 network 40.0.0.0 network 60.0.0.0 auto-summary
4	CapeRouter3	interface FastEthernet0/0 ip address 50.0.0.10 255.0.0.0 duplex auto speed auto interface FastEthernet1/0 no ip address duplex auto speed auto shutdown interface Serial2/0 ip address 60.0.0.2 255.0.0.0 interface Serial3/0 bandwidth 64000 ip address 70.0.0.2 255.0.0.0 router eigrp 10 redistribute rip metric 1000 0 255 255 100 network 50.0.0.0 network 60.0.0.0 network 70.0.0.0 auto-summary	interface FastEthernet0/0 ip address 50.0.0.10 255.0.0.0 duplex auto speed auto interface FastEthernet1/0 no ip address duplex auto speed auto shutdown interface Serial2/0 ip address 60.0.0.2 255.0.0.0 interface Serial3/0 bandwidth 10000000 ip address 70.0.0.2 255.0.0.0 router eigrp 10 redistribute rip metric 1000 0 255 255 100 network 50.0.0.0 network 60.0.0.0 network 70.0.0.0 auto-summary

Figure 2: Configuration of Routers on RIP and EIGRP Platforms.

The configurations shown in figures 2 and 3 led to the generation of the routing tables depicted in figure 4 below.

Applicable Codes for Displayed Routes C - connected, S - static, I - IGRP, R - RIP, M - mobile, B – BGP, D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area, N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2, E1 - OSPF external type 1, E2 - OSPF external type 2, E – EGP, i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area, * - candidate default, U - per-user static route, o – ODR, P - periodic downloaded static route

No	Routers	Routing Table
1	TemaRouter0	C 10.0.0.0/8 is directly connected, FastEthernet0/0 R 20.0.0.0/8 [120/1] via 30.0.0.2, 00:00:09, Serial2/0 C 30.0.0.0/8 is directly connected, Serial2/0 R 40.0.0.0/8 [120/5] via 30.0.0.2, 00:00:09, Serial2/0 R 50.0.0.0/8 [120/5] via 30.0.0.2, 00:00:09, Serial2/0 R 60.0.0.0/8 [120/5] via 30.0.0.2, 00:00:09, Serial2/0 R 70.0.0.0/8 [120/1] via 30.0.0.2, 00:00:09, Serial2/0
2	TemaRouter1	R 10.0.0.0/8 [120/1] via 30.0.0.1, 00:00:02, Serial2/0 C 20.0.0.0/8 is directly connected, FastEthernet0/0 C 30.0.0.0/8 is directly connected, Serial2/0 D 40.0.0.0/8 [90/21026560] via 70.0.0.2, 01:02:07, Serial3/0 D 50.0.0.0/8 [90/554496] via 70.0.0.2, 01:02:07, Serial3/0 D 60.0.0.0/8 [90/21024000] via 70.0.0.2, 01:02:07, Serial3/0 C 70.0.0.0/8 is directly connected, Serial3/0
3	CapeRouter2	D 20.0.0.0/8 [90/21026560] via 60.0.0.2, 01:03:50, Serial2/0 D 30.0.0.0/8 [90/21536000] via 60.0.0.2, 01:03:50, Serial2/0 C 40.0.0.0/8 is directly connected, FastEthernet0/0 D 50.0.0.0/8 [90/20514560] via 60.0.0.2, 03:54:48, Serial2/0 C 60.0.0.0/8 is directly connected, Serial2/0 D 70.0.0.0/8 [90/21024000] via 60.0.0.2, 01:03:50, Serial2/0
4	CapeRouter3	D 20.0.0.0/8 [90/554496] via 70.0.0.1, 01:04:57, Serial3/0 D 30.0.0.0/8 [90/21024000] via 70.0.0.1, 01:04:57, Serial3/0 D 40.0.0.0/8 [90/20514560] via 60.0.0.1, 03:55:55, Serial2/0 C 50.0.0.0/8 is directly connected, FastEthernet0/0 C 60.0.0.0/8 is directly connected, Serial2/0 C 70.0.0.0/8 is directly connected, Serial3/0

Figure 3: Routing Tables Built on All Routers.

RESULTS

The results obtained from the connectivity tests are as detailed below;

No	Over 64000Kbps Link	Over 10000000Kbps Link
RTT from TemaPC1 To CapePC3	C:\>ping 50.0.0.1 Pinging 50.0.0.1 with 32 bytes of data: Reply from 50.0.0.1: bytes=32 time=2ms TTL=126 Reply from 50.0.0.1: bytes=32 time=1ms TTL=126 Reply from 50.0.0.1: bytes=32 time=1ms TTL=126 Reply from 50.0.0.1: bytes=32 time=1ms TTL=126	ping 50.0.0.1 Pinging 50.0.0.1 with 32 bytes of data: Reply from 50.0.0.1: bytes=32 time=3ms TTL=126 Reply from 50.0.0.1: bytes=32 time=1ms TTL=126 Reply from 50.0.0.1: bytes=32 time=1ms TTL=126 Reply from 50.0.0.1: bytes=32 time=4ms TTL=126
	Ping statistics for 50.0.0.1: Packets: Sent = 4, Received = 4, Lost = 0 (0% loss), Approximate round trip times in milli-seconds: Minimum = 1ms, Maximum = 2ms, Average = 1ms	Ping statistics for 50.0.0.1: Packets: Sent = 4, Received = 4, Lost = 0 (0% loss), Approximate round trip times in milli-seconds: Minimum = 1ms, Maximum = 4ms, Average = 2ms
RTT from CapePC3 To TemaPC1	C:\>ping 20.0.0.1 Pinging 20.0.0.1 with 32 bytes of data: Reply from 20.0.0.1: bytes=32 time=1ms TTL=126 Reply from 20.0.0.1: bytes=32 time=1ms TTL=126 Reply from 20.0.0.1: bytes=32 time=1ms TTL=126 Reply from 20.0.0.1: bytes=32 time=1ms TTL=126 Ping statistics for 20.0.0.1: Packets: Sent = 4, Received = 4, Lost = 0 (0% loss), Approximate round trip times in milli-seconds: Minimum = 1ms, Maximum = 1ms, Average = 1ms	Pinging 20.0.0.1 with 32 bytes of data: Reply from 20.0.0.1: bytes=32 time=1ms TTL=126 Reply from 20.0.0.1: bytes=32 time=1ms TTL=126 Reply from 20.0.0.1: bytes=32 time=1ms TTL=126 Reply from 20.0.0.1: bytes=32 time=1ms TTL=126 Ping statistics for 20.0.0.1: Packets: Sent = 4, Received = 4, Lost = 0 (0% loss), Approximate round trip times in milli-seconds: Minimum = 1ms, Maximum = 1ms, Average = 1ms
RTT from TemaRouter1 To CapePC3	TemaRouter1>ping 50.0.0.1 Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 50.0.0.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 2/4/11 ms	TemaRouter1#ping 50.0.0.1 Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 50.0.0.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/13 ms
RTT from CapeRouter3 To TemaPC1	CapeRouter3#ping 20.0.0.1 Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 20.0.0.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 2/4/13 ms	CapeRouter3#ping 20.0.0.1 Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 20.0.0.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 1/4/12 ms
RTT from TemaRouter0 To CapeRouter2	TemaRouter0>ping 60.0.0.1 Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 60.0.0.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 9/11/13 ms	TemaRouter0>ping 60.0.0.1 Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 60.0.0.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 10/11/13 ms
RTT from CapeRouter2 To TemaRouter0	CapeRouter2>ping 30.0.0.1 Type escape sequence to abort.	CapeRouter2>ping 30.0.0.1 Type escape sequence to abort.
	Sending 5, 100-byte ICMP Echos to 30.0.0.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 7/11/14 ms	Sending 5, 100-byte ICMP Echos to 30.0.0.1, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 3/8/12 ms

Figure 4: Sampled Results from Connectivity Tests over Varying Bandwidths.

Table 2: Sampled Empirical Comparison of Simulated Experiment Results

Connection	Average Time Over 64000Kbps Link	Average Time Over 10000000Kbps Link
RTTfrom TemaPC1toCapePC3	2ms	1ms
RTTfrom CapePC3to TemaPC1	1ms	1ms
RTTfrom TemaRouter1toCapePC3	4ms	3ms
RTTfrom CapeRouter3toTemaPC1	4ms	3ms
RTTfrom TemaRouter0to CapeRouter2	11ms	8ms
RTTfrom CapeRouter2to TemaRouter0	11ms	8ms

Discussion of Results

The results obtained from the experiment suggests that round trip times over the 64,000 Kbps link are relatively slower than the 1,00,00,000 Kbps link, that is obviously to be expected given the logical correlation of more bandwidth implying better throughput communication over the link. Particularly given EIGRP's usage of bandwidth and delay, varied bandwidths were expected to influence the recorded round trips. The phenomena in this context was, however, subject to various metrics and contextual circumstances. The sampled results were averages of multiple echo requests that could possibly have been influenced by simultaneous propagation of broadcast updates every 30 seconds in the case of RIP and 60 seconds for HELLO packets and 180 seconds for hold-down time in the case of EIGRP. The propagations create regular surges in data transmission over the links. This phenomenon coupled with the echo requests is being used for the round-trip times measurement, which possibly could or may create some inconsistent recorded round-trip times. Further research would be required to appreciate the extent to which the surges in data transmission. As a result, inherent routing protocols' propagation influences route redistribution, given the overall results shown in figure 4 and table 2. The general round trip times over the 64,000 Kbps link are slower than the 1,00,00,000 Kbps link. The absence of specifics as to the exact cause of any possible delays are not clearly depicted, the specific contribution of the respective routing protocols to the results is also not clearly evident. The clarity of how propagations create regular surges in data transmission over the links is also not obviously evident in the results and findings. On these premises, it is recommended that further research be carried out to further appreciate the extent to which the surges in data transmission as a result of specific inherent routing protocols' propagation generally influences route redistribution.

CONCLUSIONS

This study set out to redistribute routes between RIP and EIGRP routing protocols and assess the performance beyond inherent metrics. Round-trip times over varied bandwidths were used as a basis for comparison with RIP and EIGRP used as the routing protocols. The results obtained from the experiment suggest that despite contextual subjectivities associated with route redistribution, the inherent metrics of the routing protocols do still play a significant role in determining the performance of network links with redistributed routes. The results obtained from the experiment suggest that round-trip times over the lower bandwidths are slower compared to higher bandwidths. The knowledge of regular surges in data transmission as a result of inherent routing protocols' propagation of learned routes and advertisements are not neglected in arriving at the conclusion. The results obtained from the experiment suggest that inherent metrics of the routing protocols do still play a significant role and is an integral component in determining the performance of network links with redistributed routes. Given prior knowledge of the logical correlation of more bandwidth implying better throughput communication over the link, it is however recommended that further research is done to understand the extent to which the surges in data transmission as a result of inherent routing protocols' propagation influences route redistribution.

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